OE Visualization and Controls Peer Review

Research and Development Roadmap for Integrated Security Analysis

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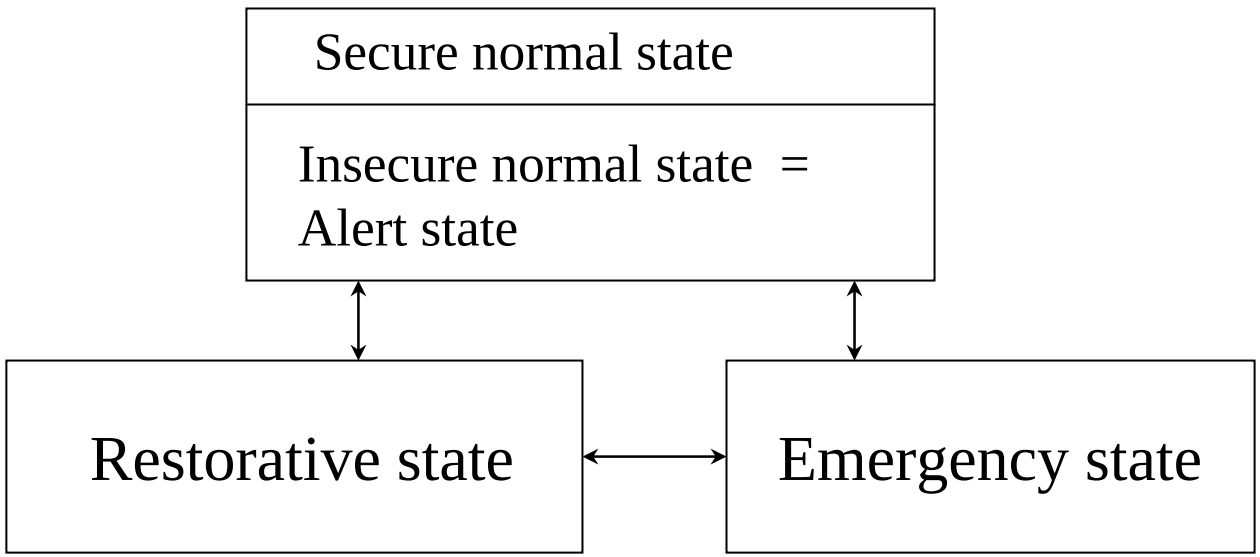
Outline

- Introduction to security analysis
- The needs of the industry
- Integrated Security Analysis Goals
- Current research efforts in security analysis as it relates to grid reliability
- A prioritized description of the technology research areas

Introduction to security analysis

- We are not talking about guns and guard dogs.
- We are talking about the 40-year-old concept of system states – normal, emergency, and restorative



Introduction to security analysis

- The normal state is “secure” if it has no violations of long-term limits and can survive each contingency in a list without violating short-term emergency limits (n-1 criteria).
- The normal state is “insecure” if one or more of the contingencies in a list will result in a violation of short-term emergency limits. This is also called the “alert” state.
- The emergency state has at least one violation of a limit and perhaps unserved load.
- The restorative state has no violations, but has unserved load.

Limits

- Thermal ratings (normal and emergency values)
- Voltage magnitude and frequency values (including transient dips/rises)
- Margin to voltage collapse
- Short-circuit current clearing capability
- Margin to steady-state instability (including minimum damping criteria)
- Margin to transient instability (including margins to relay operation)

The contingency list

- The contingency list can be very long and very complex – i.e. it could include Remedial Action Schemes (RAS), or Special Protection Schemes (SPS), or multiple events.
- The contingency list might include simple loss of elements or complex dynamic scenarios.
- The contingency list might contain very improbable events.
- The contingency list might contain very high-impact events.
- The contingency list might be political.

This project

- Evaluate industry and academic surveys
- Document industry needs
- Formulate goals
- Interpret special reports and current research
- Prioritize basic research directions

Selected needs of the industry

- Robust and accurate models inside and outside the study area
- To prioritize contingencies (by likelihood, severity or risk)
- Dynamic analysis tools designed for operations
- Something to help operators understand what they are seeing
- Operators need to know:
  - How secure is the power system now?
  - What is the security prognosis?
  - How quickly must action be taken?
  - Where are the most severe problems?
  - What mitigation actions need to be taken?

Selected needs of the industry

- Risk analysis associated with alternative mitigation measures
- Tools to analyze mitigation possibilities such as islanding
- Protective control strategies based on real-time security analysis
- Corrective control strategies based on real-time security analysis
- Identification of critical transmission corridor cutsets
- The ability to represent faults other than three phase faults
- Relating transient stability limits to system operating parameters
- Response to breaker failure contingency
- Determination of the best adjustment of transfers across cutsets
- Computation of damping levels for a synchronized region

Goals of ISA

Goal #1. Quantify margins to operational limits
(Where are we now?)

Goal #2. Provide methods to increase margins to limits
(How can we improve?)

Goal #3. Evaluate possible future
(Where will we be if a contingency occurs?)

Goal #4. Provide methods to improve security
(How can we improve?)

Goal #5. Provide real-time control if limits are violated
(How do we recover?)

Current research

- EPRI project on “Voltage and Transient Stability Region in State Space”
  - Boundaries in a two- or three-dimensional power injection space.
  - Suitable for use with the EPRI “Community Activity Room (CAR)”.
  - The Voltage Stability Region (VSR) software is expected in 2006.
  - The Dynamic Security Region (DSR) software is expected in 2007.
  - This software addresses the industry needs identified earlier for answering questions related to “How secure are we?”.
  - Issues still remain with how the boundaries to the stability region are computed in terms of current and future conditions.

Current research

- EPRI projects on “probabilistic reliability assessment and risk-based security assessment”
  - Provided a basic framework for including uncertainty in security analysis.
  - Additional work is needed in probability estimation and decision-making.
  - The contingency probability estimation is difficult because historical data is not sufficient, and real-time operations require incorporation of current conditions.
  - The decision-making aspect focuses on the need to employ preventive control when a security violation is encountered.
  - Risk-based contingency ranking needs to be investigated with respect to expanding security from N-1 criteria to N-k criteria considering risk as the deciding factor.
  - Operator interface needs to be designed and enhanced with these uncertainties and risk in mind.

Current research

- Several recent EPRI (and California Energy Commission) projects have made contributions to the overall architecture and foundations for large-scale security analysis.
  - The Common Information Model (CIM).
  - The TOPAZ project developed a reliable topology estimator. This product addresses the industry-identified need for an improved topology estimator.

- The contributions of the E2I/CEIDS projects on the Intelligrid Architecture (formerly IECSA) including Fast Simulation and Modeling have established important definitions and standardized formats for future research on grid reliability application software. They have also established a research foundation for new computing architectures that will be needed for future research in new communication and control applications.

Current research

- The current CERTS project on Adaptive Islanding has identified the issues with post-contingency response involving major deliberate topology changes to avoid cascading failures. It has also shown limited feasibility through simulated islanding in response to specific known disturbances. Many major research questions remain including determination of when islanding should be considered and the procedure for interconnection restoration.

- The current CERTS project on the utilization of substation data is investigating the potential uses for this data. The concept of distributed state estimation might well benefit from the availability of additional local information that will be coming with advanced substation metering.

Technology research areas

#1 Data and modeling issues

(State estimation and utilization of substation data)

#2 Post contingency responses

(Adaptive islanding and real-time control)

#3 Security analysis with uncertainty

(Risk-based analysis)

Technology research areas

#4 Operator visualization tools

(Alarm processing and situational awareness)

#5 Quantifying operational limits

(Boundaries and proxy limits)

#6 Dynamic Security Analysis

(Time-domain dynamic simulation)

Project impact

- Provides technical direction for basic research on power system security assessment and associated situational awareness, preventive control, and post disturbance recovery.
- Provides technical links and transitions between industry needs and research priorities.
- Provides a prioritized plan for implementation of key research projects and to deliver advances in technology at all levels.

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